

Aerospace Technology

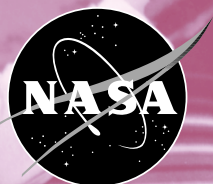
# INNOVATION

## NASA Crusades for Women's Health

Virtual Reality in Real Life Medicine

Knee Brace Commercialized

Space Shuttle Research is Earthshaking



# INNOVATION

Aerospace Technology

Volume 5, Number 6

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### About the Cover:

NASA technologies are contributing to improving the health of women around the world.

**On-Line Edition:** Go to <http://nctn.hq.nasa.gov> on the World Wide Web for current and past issues.

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## COMMERCIAL DEVELOPMENT MISSION UPDATE

Date*	Flight	Payload	Sponsor/Coordinator
1/98	STS-89 Shuttle/Mir-08	ASTROCULTURE(TM)** X-ray Detector Test** Commercial Generic Bioprocessing Apparatus*** Liquid Phase Sintering (samples)***	Wisconsin Center for Space Automation and Robotics Center for Macromolecular Crystallography BioServe Space Technologies Consortium for Materials Development in Space
5/98	STS-91 Shuttle/Mir-09	Commercial Protein Crystal Growth (CPCG-11) (Protein Crystallization Facility configuration, "sortie" mode)	Center for Macromolecular Crystallography
8/98	STS-93 AXAF	AEROGEL (under consideration for assignment)	Marshall Space Flight Center
10/98	STS-95 BioTechHab (SPACEHAB short module)	To be defined; to include as many as 12 commercial development payloads covering several areas of research, in addition to other payloads	Planned payloads represent about six Commercial Space Centers and NASA Centers with an emphasis on commercial development of space in the area of biotechnology

Key STS—Space Transportation System

\*As of 9 January 1998 \*\*These payloads will be accommodated on Mir for extended operations of about four months and will be returned on Shuttle/Mir Mission-09.

\*\*\*These payloads were launched on STS-86 (Shuttle/Mir Mission-07) and are returning from extended operations on Mir.



# WELCOME TO INNOVATION

## "There's Space in My Life..."

by Terri Hudkins  
Women's Outreach Initiative

**N**ASA'S RESEARCH AND TECHNOLOGY IS NOT just about distant galaxies, astronauts and supersonic aircraft. The science and engineering that make NASA's programs possible touch lives every day. This influence is most apparent in the field of medicine where innovative thinking has made it possible to adapt deep space technology to understanding, detecting and treating cancer. NASA's research is designed to learn how to fly higher and faster, and about how to live and work in space. Its application, however, often hits much closer to home.

To share information about how NASA science, research and technologies improve the lives of women, men and their families, NASA has begun an innovative, two-year initiative to reach women and their families called, "There's Space in My Life." The initiative originated with NASA Administrator Daniel S. Goldin who wants to share information about how aerospace is an investment in our current standard of living, in our knowledge of our place in the universe and in our children's future.

Recognizing the importance of 21st Century technologies in women's health, NASA's Ames Research Center and the US Department of Health and Human Services' Office of Women's Health signed an historic agreement in October 1997 to work more closely on a number of technologies to benefit women's health. The two agencies will focus their efforts on cancer, reproductive health, pregnancy, osteoporosis and education. Several members of Congress were there to mark the occasion and lend their support. The Congressional Caucus on Women's Issues held a luncheon immediately following the signing, entitled, "Space Technology Contributions to Breast Cancer Research." Several members of Congress and a senator shared their personal stories about cancer. This disease touches almost everyone in our society.

During Breast Cancer Awareness Month in October, we created and wrote feature stories, with help from the Technology Transfer and Commercialization offices, and conducted over 100 live interviews with television stations across the US about how NASA technology is offering hope in the fight against this dreaded disease.

Featured in this issue of Innovation are highlights of the technologies in use today and being developed for tomorrow, that help doctors find and treat breast cancer, one of the leading causes of death among American women.

The importance of innovative thinking is brilliantly demonstrated with NASA's application of Hubble Space Telescope technology in improving the first line of defense against breast cancer: regular mammograms. Who would have thought that the technology used to pinpoint specific stars among the millions in the galaxies could be used to find the tiniest abnormalities in breast tissue? This is not science fiction, but science fact, in your doctor's office today.

NASA is reaching out to women and families to let them know how their space and aeronautics tax dollars are being applied right here on Earth—not only in cancer research but in many other

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areas of particular interest to women. Much of NASA's research in health and medicine is especially important to women, because many of the troublesome symptoms experienced by astronauts in space flight are similar to conditions that affect many women on Earth, such as osteoporosis.

We are very excited about this new initiative on technologies "twice used," once for NASA's principal mission in space and aeronautics, and again, for other purposes in the form of products and services, that directly affects us all. Indeed, NASA's less often stated mission is to improve the quality of life on Earth.

Upcoming campaigns will include feature stories, brochures, events and a website for families on the topics of health and fitness, travel and leisure, home and garden, safety, and exploring the mysteries of Earth and the universe.

Look for updates in future issues of *Innovation*. ✱

# TECHNOLOGY TRANSFER

## NASA Crusades for Women's Health

### *Space Technology Used to Detect and Treat Breast Cancer*

**N**ASA IS TAKING THE LEAD IN THE FIGHT against breast cancer and other women's illnesses by outlining a commitment to identify, develop and transfer NASA technologies to benefit women's health.

Major areas of concern are cancer, reproductive health, pregnancy, osteoporosis and education, outlined in a recently signed NASA agreement with US Department of Health and Human Services' Office of Women's Health that established a cooperative framework with Ames Research Center.

In addition to exploring space and developing aeronautics, NASA is charged with applying its technology to improve the quality of life.

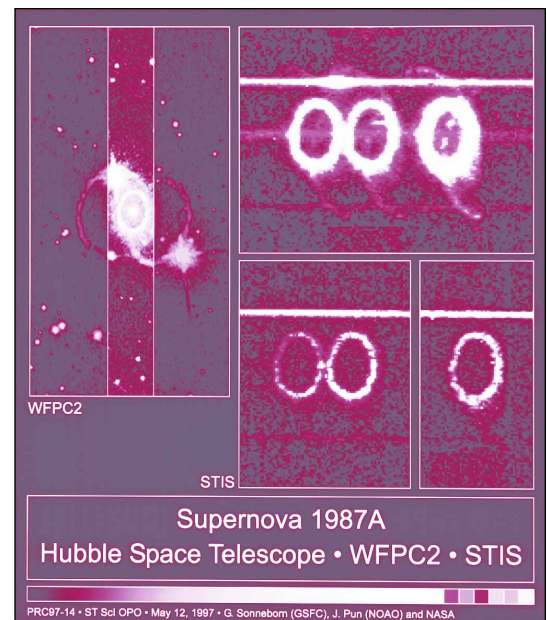
Teaming with industry, academia and government, several NASA biomedical experiments have resulted in successful new technology programs between NASA, the National Institutes of Health, the National Cancer Institute and the U.S. Department of Health and Human Services' Office on Women's Health.

*Technology derived from Hubble Space Telescope (HST) enables doctors to perform stereotactic needle biopsy procedure on women.*

### *In Your Doctor's Office Today*

### Digital Breast Imaging Technology

Silicon chips in the Hubble Space Telescope that convert a distant star's light directly into digital images have been adapted so doctors can easily detect tiny spots in breast tissue. Locating the



*(Above) Hubble Space Telescope Imaging Spectrograph (STIS) provides a new and unprecedented look at one of the most unique and complex structures in the universe.*

exact spot allows doctors to analyze the tissue using a needle rather than by traditional surgery. This procedure is less painful and less traumatic for the patient and eliminates scarring or disfigurement. The new procedure requires half the time of traditional techniques and reduces approximate costs from \$3500 to \$850.

This new technology images breast tissue more clearly and efficiently than conventional x-rays. Both the Hubble Telescope and mammograms require similar technology: high resolution to see fine details; wide dynamic range to capture in a single image structures spanning many levels of brightness; and low light sensitivity to shorten exposure and reduce x-ray dosage. While this highly sensitive Hubble-based technology is





improving breast cancer detection, scientists working with Hubble at NASA's Goddard Space Flight Center, Greenbelt, Maryland, continue to refine and develop this technology.

## ***Tomorrow's Technology***

### **Next Generation Digital Imaging Mammography**

Space-based instruments used to study the atmosphere may soon have a place in the medical examination room, possible because atmospheric studies and mammography both require compact, reliable, low-power sensors and digital computers. The approach of NASA's Langley Research Center, Hampton, Virginia, will be faster, safer, easier to use and save countless lives.

This new approach is significant because it can accommodate different tissue density. This is particularly important for younger women, who have more dense tissue than older women. NASA is working with the National Institutes of Health on a prototype that would create an image of the entire breast with superior resolution.

The computer scans each part of every mammogram image and reports any suspicious areas. The electronic images can then be transmitted to other experts if more opinions are needed. Using the best mammogram technique currently available, tumors as small as 0.2 mm, about the thickness of a piece of thread, have been detected. The goal of digital mammography is to identify clearly tumors as small as 0.1 mm.

### **Advanced Ultrasound Technology**

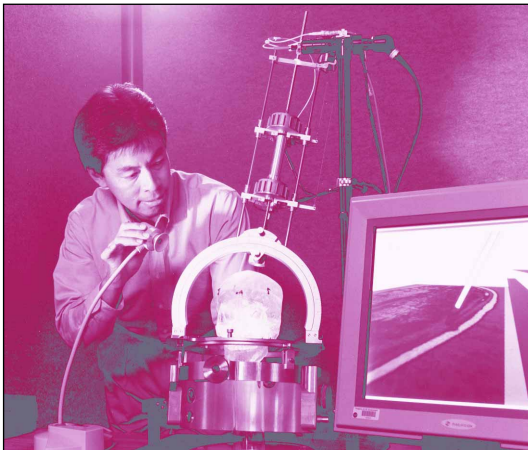
Technology developed to improve the quality of pictures from Mars Pathfinder is being modified to make three-dimensional models of breast tissue. The NASA effort, led by scientists at NASA's Ames Research Center's Computational Sciences Division, Moffett Field, California, combines ultrasound with advanced computing, automated learning and high-resolution imaging techniques developed for space missions.

Using the three-dimensional model, physicians will be able to differentiate between cancerous and healthy tissue without painful invasive procedures. The experimental system also will discern differ-

ences in tissue by comparing changes in shape and by analyzing the ultrasound signal. The system will potentially improve cancer treatment by focusing ultrasound signals on cancerous tissue without destroying healthy tissue.

### **Smart Robot Probe for Cancer Detection**

NASA technology being developed to perform surgery on astronauts in space is being adapted to robotic technology to help physicians operate on delicate parts of the human body, including the



*Dr. Robert Mah of NASA Ames Research Center, Moffett Field, California discusses design of a real-time biopsy probe for breast cancer detection with Dr. Stephanie Jeffrey, chief of breast surgery at Stanford University School of Medicine (above). The probe pictured here comes from the NASA robot brain surgeon that can learn the physical characteristics of the brain.*

## TECHNOLOGY TRANSFER

brain and the breast. Led by the NeuroEngineering Group at NASA's Ames Research Center, scientists have developed a robot that can map physical characteristics of the brain, allowing the surgeon to make precise movements during surgery. The technology is being modified further to have the robot feel tumors in other parts of the body to determine severity and appropriate treatment.

The experimental robot can use a smaller, less invasive probe, and it can make more delicate and precise movements than a human, thus reducing damage to healthy tissue and arteries.

### Tele mammography

For women living in remote areas, access to mammography experts may be hundreds of miles away. Tele mammography, the electronic transmission of digitized mammograms, can connect patients in rural locations with medical experts across the country.

NASA technology will help provide quality medical diagnosis and information services to remote areas in a faster, more cost-effective manner than the current costly telephone line transmission that can take hours.

NASA's Lewis Research Center, Cleveland, Ohio, working with breast cancer research hospitals,

including the Cleveland Clinic and the University of Virginia, is performing critical research to allow new satellite networks to support tele mammography.

### Tissue Growth in the NASA Bioreactor

NASA's Johnson Space Center, Houston, Texas, is leading a project using the microgravity of space to assemble and grow human tissue for research and transplantation.

The bioreactor is a special tissue culture chamber designed by NASA to engineer tissue. Scientists hope to create a three-dimensional (3-D) tissue culture and send it to the Mir Space Station in early 1998. One of the first experiments in this unique environment will allow cancer tissue to be assembled and grown from individual cells. The three-dimensional tissues are crucial to understanding cancer and how the human immune system responds. The bioreactor permits scientists to grow cells similar to tissues found in the human body. By testing three-dimensional tissues for sensitivity to chemotherapy and hormonal therapy, researchers gain valuable knowledge important to the treatment of breast and ovarian cancer. ✱

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For more information, contact Terri Hudkins at NASA Headquarters. ☎ 202/358-1977 📠 202/358-4341 ✉ [teresa.hudkins@hq.nasa.gov](mailto:teresa.hudkins@hq.nasa.gov)  
Please mention you read about it in *Innovation*.

*High-quality, high-resolution mammography images can be delivered from rural to urban sites in a faster, more cost-effective manner via the Advanced Communications Technology Satellite (ACTS), pictured below, a high-access global satellite network operated by NASA Lewis Research Center.*





# Finding Breast Tumors More Accurate in 3-D

**I**DENTIFYING BREAST TUMORS MAY SOON BE easier, clearer and more accurate with a pair of 3-D glasses and software from Ames Research Center that combines a series of scans to form a high fidelity 3-D computerized picture, or "reconstruction," of a breast and tumor.

Each high fidelity 3-D picture is known as a "reconstruction," a computerized object that a physician wearing 3-D glasses can see from all angles on a computer monitor.

"These reconstructions are highly accurate 3-D visual models of affected breasts with tumors. Once this technique is fully developed, we think physicians will be able to visualize the borders of tumors more clearly," said Dr. Muriel Ross of NASA's Ames Research Center, Moffett Field, CA. Ross is director of the Ames Biocomputation Center which uses computer technology to improve medical practices.

In the new technique, a series of Magnetic Resonance Imaging (MRI) breast scans are combined to make a 3-D image using Reconstruction of Serial Sections (ROSS) software that was developed in the Biocomputation Center. The method eliminates "noise," or interference, seen in more common renderings of breast tissues done in many clinics.

"For this initial reconstruction, we combined features of the ROSS software we have been using with another version we use for Computed Axial Tomography (CAT) scans," Ross said. "Eventually, a special version of the software will be developed for MRI. In the meantime, we have demonstrated that high fidelity, 3-D reconstructions can be made from typical MRI breast scans."

Normally, mammograms are used for initial screening for breast cancer. If a suspicious lump is detected, a follow-up MRI using contrast medium can be conducted. "The medium is injected into the patient's blood stream. This medium rapidly concentrates in the tumor which shows in the scan as a

bright area. But even with this technique, it is hard to see where the tumor begins and ends," Ross said.

"Later, we intend to work with sonograms," she said. A sonogram is a scan that uses sound to visualize objects inside bodies. "We want to reduce noise that comes from multiple, echo-like reflections of sound coming from tissues. Borders of objects can be difficult to define because echoes bounce and can interfere with one another."

The NASA Biocomputation Center at Ames will become part of a larger National Biocomputation Center soon to be established by NASA and Stanford University, Palo Alto, CA, according to Ross. "The new center will be a national resource to further the use of virtual reality in medicine," Ross said. Virtual reality is a computer-created environment that simulates a real-life situation.

The Biocomputation team is interested in working with mastectomy patients needing breast reconstruction, and with children who need reconstructive surgery to correct deformities of the head and face. Eventually the system could be used in

IDENTIFYING BREAST TUMORS MAY SOON  
BE EASIER, CLEARER AND MORE  
ACCURATE WITH A PAIR OF 3-D GLASSES  
AND SOFTWARE . . .

other medical specialties or surgical procedures.

Virtual reality will allow surgeons to rehearse complex procedures before an operation. In addition, the team expects virtual reality will be a powerful teaching tool for medical students. A digital library of computerized "virtual patients" will be created that physicians can use to share information about uncommon procedures, according to researchers.

Development of the breast tumor enhancement software follows an agreement that enlists NASA technologies to fight breast cancer and other women's illnesses. The agreement was signed in October in Washington, DC, by representatives of NASA and the Department of Health and Human Services. Major areas of concern are cancer, reproductive health, pregnancy, osteoporosis and education. ✱

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For more information contact Dr. Muriel Ross at Ames Research Center.  
☎ 650/604-4804, ☎ 650/604-3954, ✉ mross@mail.arc.nasa.gov or  
write NASA Ames, MS 239-11, Moffett Field, CA. Please mention you read  
about it in *Innovation*.

# ADVANCED TECHNOLOGIES

## New Shades Help Drivers and Pilots

**A** MODIFICATION TO A FILTER NASA ENGINEERS already developed for current use with agricultural goggles may make skies and roads safer by helping daytime pilots and drivers to see better.

A new sunglass filter, designed by Portland, Oregon company Optical Sales Corp., was adapted from a filter originally developed to help farmers identify diseased plants by enhancing the human eye's capacity to detect other colors in the visible spectrum by blocking yellow and green light during daylight hours.

The original filter, a low-cost, brownish, plastic material called the passive chlorophyll detector, was developed in 1991 by Dr. Leonard Haslim of NASA's Ames Research Center, Moffett Field, California.

"If we diminish or block a lot of the yellow-green light that the eye normally sees, suddenly the other colors stand out in much greater relief. This lets us see colors much more clearly, like we see them at the movies," Haslim said.

According to Haslim, stress in plants tends to be camouflaged by the plant's natural chlorophyll. As a result, many plant diseases cause irreversible damage by the time they become visibly evident. In the



*Special brown sunglass filters, developed by Dr. Haslim for agricultural use helps agricultural workers spot plant stress and disease.*

past, it was necessary to have highly trained professionals examine plants in order to determine signs of stress in the early stages. Haslim said that he developed his filter to address that need.

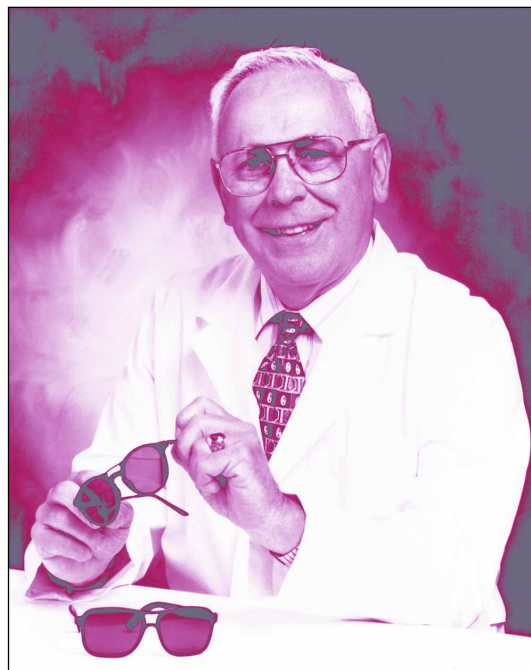
"Now, farmers themselves can use goggles equipped with the special filter to locate diseased or stressed plants," said Haslim. "Sick leaves that appear just a bit yellow in normal light show up as a much brighter yellow when viewed through the filter. Conversely, healthy leaves appear as a vivid green," Haslim said.

The sunglass adaptation with the modified filter was first made commercially available in early 1997. ✱

For more information, contact Dr. Leonard Haslim at Ames Research Center.

☎ 650/604-6575, ☎ 650/604-6996, ✉ NASA Ames, MS 237-11, Moffett Field, CA, 94035-1000. Please mention you read about it in *Innovation*.

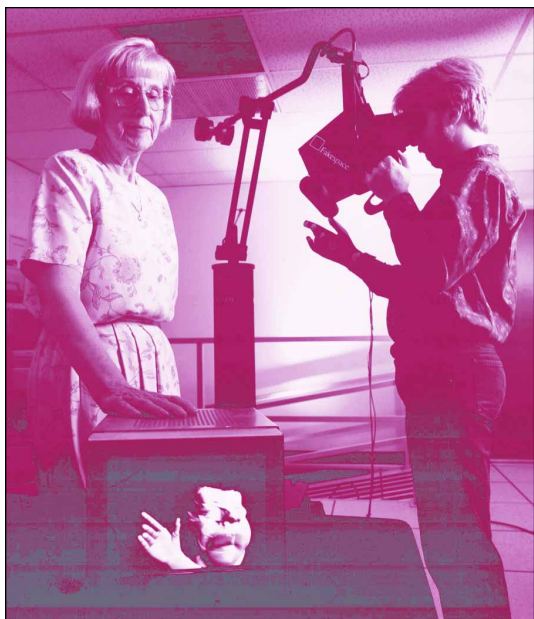
*Dr. Leonard Haslim of NASA Ames Research Center holds glasses equipped with brown agricultural filters he developed. Glasses on table hold filters, developed by Haslim, for chlorophyll detection.*



## Virtual Reality in Real Life Medicine

**C**OMPUTER TECHNOLOGY TO IMPROVE MEDICAL practice using virtual reality is one of the major goals of the National Center for Biocomputation soon to be established by NASA and Stanford University, Palo Alto, California. A letter of intent was recently signed by NASA and Stanford to locate the Center at Stanford.





*Dr. Kevin Montgomery of Ames works the virtual environment boom as Dr. Muriel Ross looks on. The glove on Montgomery's right hand allows him to manipulate the image on the monitor. Eventually, the glove will enable surgeons to "use" surgical instruments to practice surgery on the 3-D image on the monitor.*

New medical technologies developed at the Center will improve the ability of patients and surgeons to see outcomes before surgery is done; create a digital library of computerized "virtual patients" to be used to teach medical students and help physicians share information on uncommon surgeries.

A virtual hospital could be established by the year 2000, according to some Center researchers, which may eventually link the best medical minds from around the country and world to treat patients, simultaneously benefiting long-term human space presence by assisting in emergency medical treatment of future space travelers.

This collaboration "will help change forever medical practice and the teaching of science and medicine" which will revolutionize the way surgery is done, said Dr. Muriel Ross, director of the NASA Biocomputational Center at Ames.

"The physician can go in the night before surgery and use the computer in a virtual environment to actually walk through the operation."

The NASA-Stanford biocomputational team has already developed virtual reality computer tools to

aid in complex facial reconstructive surgery. Surgeons can use a big-screen workbench, special gloves, computer tracking wands and software to manipulate a 3-D computer image of the patient.

"The surgeon can work on the virtual reality image and replace the soft tissues to see what the patient may look like after facial reconstruction. If the doctor doesn't like what he or she sees, it's easy enough to start all over again," Ross explained.

"Working together, Stanford Medical Center and Ames Research Center can accomplish more than either could acting alone," Ross said. "But even our considerable resources are likely insufficient to take on and solve all the challenges that lie ahead. We shall seek out partnerships with other academics, federal agencies and industry to accelerate the day when use of 3-D and virtual environment technologies are commonplace in science and medicine as well as in space." ✱

For more information contact Dr. Muriel Ross at Ames Research Center.

☎ 650/604-4804, ☎ 650/604-3954, ✉ mross@mail.arc.nasa.gov or write NASA Ames, MS 239-11, Moffett Field, CA. Please mention you read about it in *Innovation*.

## NASA Technology for Water Comes Clean

**T**ECHNOLOGY THAT MADE DRINKING WATER possible for NASA Apollo space mission astronauts and yielded numerous water filtration products for down-to-earth water consumers, has been commercialized again to provide a cost-effective means for cleaning cooling water without using biocides and adding significant potential economic value.

Natural Water Technologies, Inc., Atlanta, Georgia; the PMG Manufacturing Group, Wheeling, West Virginia; and the National Technology Transfer Center partnered to reengineer NASA's copper-silver ionizer, a technology developed at Johnson Space Center, to create a new inexpensive, chemical-free, water cleaning product called BIO-CLEAR™.

Traditionally, cooling water treated by chemical means requires expensive, toxic compounds and close monitoring of the cleaning process to ensure employee safety.

### KNEE BRACE COMMERCIALIZED

An update to a promising technology first introduced in the January/February '97 issue of *Innovation*, the Selectively Lockable Knee Brace is on its way to being commercialized—it has been licensed.

This innovative knee brace facilitates faster, less painful rehabilitation of knee problems and muscle weakness as high as the thigh, allowing freer knee movement.

Horton's Orthotic Lab, Inc., of Little Rock, Arkansas, has signed a licensing agreement with NASA's Marshall Space Flight Center in Huntsville, Alabama, for the device that offers support to the leg while allowing knee function to the recovering knee injury or surgery patient who may need to use the knee while, at the same time, can't carry full weight on the knee, according to the rocket engineers and/or inventors.

Michael Shadoan, Neill Myers, and co-inventors John Forbes, Kevin Baker and Darron Rice worked for three years to develop the prototype, designed as a spin-off of space propulsion system mechanisms and materials.

Knee braces currently on the market lock the knee in a rigid, straight-leg position, while the new brace design "works by allowing the knee to bend when weight is not on the heel," said Myers. "Once weight is placed on the heel, the knee brace locks into position."

The upper part of the brace attaches around the thigh with the lower part secured by a stirrup around the shoe.



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For more information about the product, contact Michael Shadoan at Marshall Space Flight Center. ☎ 205/544-5276, ✉ michael.shadoan@msfc.nasa.gov, or contact Tony Miller of Horton's Orthotic Lab ☎ 501/663-2968, ✉ TMiller@Hortonsoandp.com Please mention that you read about it in *Innovation*.

The BIO-CLEAR™ system, a mechanical water cleaning system device, cleans water supplies without chemicals in process plants such as steel mills, paper mills and chemical mills.

The average BIO-CLEAR™ system used for industrial cleaning costs \$20,000 and provides a typical two-year return on investment. It has resulted in six immediate new jobs with the possibility of 30–50 jobs in three to five years; \$500,000 in new business in one year; potential for \$15–\$20 million in increased revenues; and potential wide use in new housing developments, small community drinking water processes, third world communities and isolated areas.

BIO-CLEAR™ eliminates downtime associated with most chemical-based water cleaning systems by treating the total volume of water from an average source every six hours, at a processing rate of 25 gallons per minute. This self-cleaning system is set up to clean on a 24-hour cycle, an advantage

over most 36–48 hour systems.

BIO-CLEAR™'s innovative three-phase process can be set up and monitored by a single operator. The stages include an advanced filter system, followed by a patented magnetic media for bacteria removal and then exposing the water to a high intensity UV light source for immediate and optimum kill rates for bacteria.

Currently, BIO-CLEAR™ technology is breaking into the industrial communities and is anticipated to expand domestically and internationally in commercial water cooling towers; potable water for hospitals, hotels and municipalities; and individual or residential use for home and spas. ✱

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For more information about BIO-CLEAR™, please contact Yuriy Wowczuk at the National Technology Transfer Center. ☎ 304/243-3466, ✉ ywowczuk@nttc.edu or Natural Water Technologies, Inc., 6635 Brandon Mill Road, Atlanta, GA 30328, ☎ 404/303-0068. Please mention you read about it in *Innovation*.



# AEROSPACE TECHNOLOGY DEVELOPMENT

## Low Visibility Tests May Significantly Increase Air Safety

**I**MPROVING AIRPLANE TRAFFIC SAFETY IN LOW visibility with reductions in ground accidents, close calls and miscommunication looks promising following NASA's recent tests and technology demonstrations in the eastern U.S.

Demonstrations of NASA and Federal Aviation Administration (FAA) aircraft technology on the runways and taxiways of Hartsfield-Atlanta International concluded that reductions were possible by increasing situational awareness of pilots and controllers by using a combined ground and airborne system with computer generated graphics.

The overall system integrates many technologies including ground surveillance sensors and other equipment developed by the FAA onboard NASAs Boeing 757 research aircraft.

The research is part of NASA's seven-year Terminal Area Productivity program begun in 1994, and is led by NASA's Ames Research Center, Moffett Field, California. It is expected to substantially increase aviation system traffic capacity in all weather conditions.

Dubbed the Low Visibility Landing and Surface Operations program, the Atlanta effort's cockpit display system gives the pilot a "heads-up" display, which was developed at Ames.

As the research aircraft approaches the runway, computer-generated graphics outline the correct runway and its precise location on a glass visor mounted between the pilot and the cockpit windshield. Upon contact with the ground, the pilot's aircraft position and that of other aircraft are displayed on an electronic moving map of the airport on the instrument panel.

With Global Positioning System (GPS) satellite positioning and an airport layout database, the displays are updated in real-time. The glass visor, or head-up display, shows the edges of the runway and taxiway with a series of computer-generated "cones" in a virtual reality manner. During taxiing, a turn is indicated by virtual cones and signs showing the angle and direction of the turn. As the pilot taxis, the virtual cones and signs move and change as if they were actual objects on the taxiway. The pilot's cleared route looks like a virtual highway on the ground.

Ground-based components consist of a surveillance system that provides traffic positions to the 757 via a

computer datalink and a controller interface that allows air traffic controllers to transmit instructions to the aircraft by computer in parallel with normal voice communications. The controller also is automatically informed via this computer link if the 757 deviates from its approved path.

Other flight demonstrations have been held in Iowa, New York, Minnesota, Massachusetts, Colorado, Maryland and Virginia. ✱

For more information, contact Dr. Robert McCann at Ames Research Center.

☎ 650/604-0052, 📠 650/604-3323, ✉ rsm@eos.arc.nasa.gov Please mention you read about it in *Innovation*.



*NASA researcher checks out research pallet in NASA 757 research aircraft before sending to Atlanta Hartsfield International Airport.*

## Future Space Rocket Engines Tested

**T**HE FIRST IN A SERIES OF IN-FLIGHT qualification tests of a linear aerospike engine recently at NASA's Dryden Flight Research Center, Edwards, California, may help lower costs in space access, achieve optimum performance and efficiency, and create new space services and activities.

The NASA/Rocketdyne/Lockheed Martin Linear Aerospike SR-71 Experiment (LASRE), which includes a half-span, one-tenth-scale model of the RLV engine is being tested to power in 1998, and is designed to gather data on the aerospike's performance as it travels the transonic flight region.

Its plumbing and accessories are very similar to a normal rocket engine. The major difference is the absence of a bell-shaped nozzle. For optimum engine performance and efficiency, the atmosphere serves as part of the aerospike's nozzle with the rocket's exhaust plume contained in the surrounding airflow—allowing it to compensate for atmospheric changes, unlike traditional rocket engines.

The linear aerospike's 75 percent shorter length design means less engine weight and less engine support structure required, allowing for a lighter vehicle and lower vehicle launch costs.

## AEROSPACE TECHNOLOGY DEVELOPMENT

The model contains eight thrust cells of an aerospike engine mounted on a housing containing gaseous hydrogen, liquid oxygen and instrumentation and together are called the "pod." The SR-71 takes off for aerial refueling with a tanker aircraft. With the piggy-backed LASRE pod, the SR-71 reaches an altitude between 20,000–80,000 feet.

Soon, the linear aerospike will be fired to collect accurate in-flight data on the interaction of the RLV's airflow and the linear aerospike engine and its exhaust plume. This data also will help determine the efficiency of the rocket engine.

Existing for more than 30 years, linear aerospike rocket engines have never flown until now. The technology at the time was considered too immature and was rejected by the Space Shuttle program. Now new material technology, modern performance sensors and monitoring controls enable split-second engine control with improved aerospike engine thrust cells modernized by additional laboratory tests and ground firings. More than a \$500 million investment from Rocketdyne (a part of The Boeing Company) the Air Force and NASA has been made over the prior 30 years on aerospike technology.

NASA and industry are currently engaged in a cooperative agreement, the Reusable Launch Vehicle Program (RLV), to increase U.S. economic competitiveness and

continued commercialization of the national space launch industry through the National Space Transportation Policy. The RLV program consists of both the X-33 and the X-34 technology demonstrators. The smaller X-34 will test the feasibility of launching small commercial and scientific payloads aboard a reusable rocket.

The X-33 is a technology demonstrator for a Single-Stage-To-Orbit (SSTO) RLV. The goal of the RLV technology program is to enable significant reductions in the cost of access to space, and to promote the creation and delivery of new space services and other activities that will improve U.S. economic

competitiveness. The program implements the National Space Transportation Policy, which is designed to accelerate the development of new launch technologies and concepts to contribute to the continuing commercialization of the national space launch industry. ✱

For more information, contact David Lux at Dryden Flight Research Center. ☎ 805/258-3695, 📠 805/258-2793, ✉ Dave.Lux@dfrc.nasa.gov or contact Carl Meade at the Lockheed Martin Skunk Works. ☎ 805/572-3908, 📠 805/572-5798, ✉ Carl.Meade@lmco.com Please mention you read about it in *Innovation*.

## Virtual Laboratory Expands NASA Research

**A**STRONAUTS AND ENGINEERS HAVE successfully concluded tests on a computer-generated virtual laboratory that will allow researchers—located anywhere in the world—to study potentially dangerous aircraft and spacecraft situations without risking human life.

"The lab can enable research organizations and many other parties to collaborate long-distance for the first time—without having to be physically present at the world's largest flight simulator at NASA's Ames Research Center, Moffett Field, California," said the lab's project manager, Tom Alderete.

"It could also be used by universities, research laboratories and industry to develop a wide variety of products beyond the aerospace field," he said. Future uses of the laboratory also being considered include design of new spacecraft and training for astronauts made possible, again, by use of the computer-generated "virtual" laboratory and not requiring physical presence.

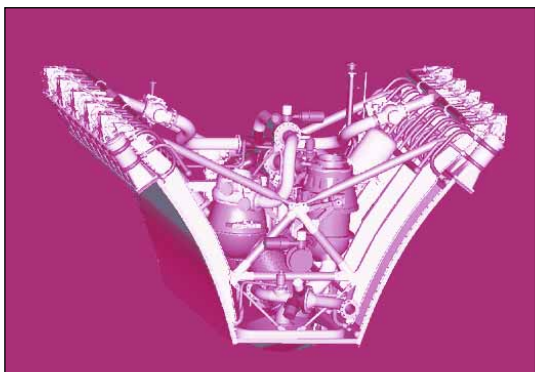
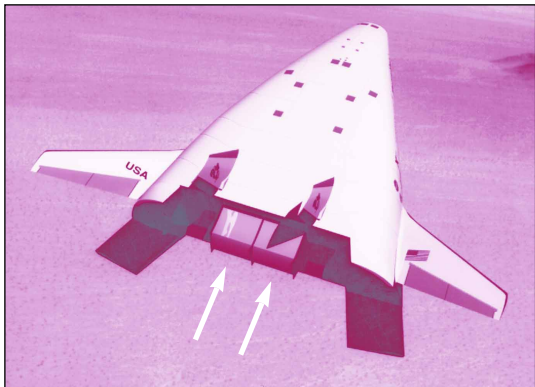
Ames' simulator is able to move airplane and spaceship cockpits in all directions, including 60 feet vertically and 40 feet horizontally. There are five interchangeable cockpits that are used to simulate the Space Shuttle, helicopters, airplanes and other aerospace vehicles.

Researchers study aerospace controls, guidance, cockpit displays, automation and handling qualities of existing or proposed aircraft or other vehicles. The simulator creates a convincing environment for a pilot and is controlled by computers programmed to represent each aircraft.

Computers calculate correct aircraft response when a pilot changes simulator cockpit controls. In real-time, responses by the simulator include cockpit motion, images in the windshield, sounds and control readouts. Simulations are monitored from control labs at Ames.

(Top) Arrows indicate the linear aerospike engines on Lockheed Martin's X-33 Advanced Technology Demonstrator.

(Bottom) X-33 linear aerospike engine diagram.





The virtual laboratory's data communications are enabled by the NASA Research and Education Network. According to the network's project manager, Christine Falsetti, "Experience with real-time computer files that the virtual lab uses also helps us learn how to better use computer networks to help do research in the future." The virtual laboratory and the "world" it creates exist partly in computer memory and other physical gear.

In June 1997, astronauts made simulated Space Shuttle landings using a huge motion simulator at Ames while NASA engineers in Houston monitored the sessions using the three-dimensional "world" that includes video screens, computer video, two-way video conferencing, shared whiteboards, remote data access and a pilot's out-the-window scene. ✱

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For more information contact Dr. Muriel Ross at Ames Research Center. ☎ 650/604-4804, ☎ 650/604-3954, ✉ mross@mail.arc.nasa.gov or write NASA Ames, MS 239-11, Moffett Field, CA. Please mention that you read about it in *Innovation*.

## Space Shuttle Research Is Earthshaking

**T**ECHNOLOGIES DEVELOPED BY NASA TO protect delicate experiments from minor vibrations and movement aboard the Space Shuttle in orbit are being applied to reduce damage to buildings and bridges from major vibrations during severe earthquakes and high winds.

"Right now we're working on developing technological 'tools' which architects and construction engineers can use when designing more earthquake-tolerant structures and in enabling existing structures to better survive earthquakes," said Dr. Mark S. Whorton, an aerospace engineer at Marshall Space Flight Center in Huntsville, Alabama, who has been working for years to resolve microgravity environmental vibration problems that affect sensitive science experiments.

"There are several ways to reduce the effect of structural vibrations. A direct approach is to stiffen the structure, which requires changing its mass and therefore its vibration characteristics. While this may be acceptable for many terrestrial applications, the need for strong but light-weight structures in space renders this option infeasible for NASA," Whorton said.

"Clearly, for applications in the space program, light-weight but equally effective vibration mitigating alterna-

tives were needed. We found that these technologies had down-to-earth applications as well. One way of countering structural vibrations caused by a strong gust of wind or seismic ground motion is to place sensors and force producing devices called actuators at specific locations on buildings. As sensors in the system measure the motion of the structure, actuators apply forces to counteract the structure's vibrations," Whorton said.

"One such force device would use hydraulic pistons moving counterweights. Another method involves placing adjustable tendons along the sides of structures. In fractions of a second, sensors in the systems can read the structural vibration patterns caused by earthquakes or high winds and adjust the tension on the appropriate tendons to reduce the excessive forces or motions of the building," Whorton said.

"The active control technology for vibration isolation is mature and is fully capable of doing the job. This is a technology ready now for commercial applications," Whorton said.

Of the actively controlled buildings in operation today, all are in Japan with the exception of one in Taiwan. A TV tower in Nanjing, China will also be retrofitted with active vibration control. Other new construction will incorporate the technology, particularly in seismically active regions; and, of course, it may be possible to retrofit the technology to other existing structures. ✱

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For more information, contact Jerry Berg at Marshall Space Flight Center. ☎ 205/544-6540, ☎ 205/544-5852, ✉ Jerry.Berg.msfc.nasa.gov Please mention you read about it in *Innovation*.

## NASA AND ARGENTINA SIGN AGREEMENT

**A** memorandum of understanding (MOU) between NASA and the Argentina National Commission on Space Activities (CONAE), was signed recently to launch Argentine satellites SAC-C and SAC-A of the Satellite de Aplicaciones Cientificas for experiments and technology testing in numerous areas to benefit both the Argentine and U.S. Space programs.

SAC-C will conduct correlated observations of the Earth of interest to Argentina and the United States, and also will contribute directly to the NASA Mission to Planet Earth Program. NASA will launch the satellite, currently scheduled for a Delta rocket, in May 1999.

SAC-A will be launched as a hitchhiker payload from the Space Shuttle cargo bay in 1998 on the STS-88 mission, which also is the first Space Station assembly mission. The small Argentine-built satellite will test several new space technologies for the Argentine and U.S. space programs.

The signing of these agreements reflects the continued growth and importance of civil space cooperation between NASA and CONAE. Argentina opened the doors to a partnership with NASA, establishing CONAE in 1991, and a framework agreement was signed. The level of cooperation has increased significantly since then. NASA and Argentina also are cooperating on ozone investigations and protein crystallography investigations aboard the Space Shuttle.

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For more information, contact Douglas Isbell at NASA Headquarters. ☎ 202/358-1753. Please mention you read about it in *Innovation*.

# SMALL BUSINESS/SBIR

## Increased Chances For Phase III

**P**ARTICIPANTS COMPLETING PHASE II OF NASA's Small Business Innovation Research (SBIR) Program may have a better chance at successful commercialization in Phase III.

Phase II awardees of NASA's Small Business Technology Transfer Program presented innovative biomedical projects to an expert review board in November at a NASA Technology Commercialization Review in Houston, Texas, the first of many, with varied focuses, to be conducted by the National Technology Transfer Center (NTTC).

NASA representatives have tasked NTTC to guide participants toward successful partnerships and commercialization.

"Our panel of experts in the technology and business commercialization field provided participants with the missing links," NTTC Director of Operations Sunni Richmond said. "The participants have the technologies that have been fully developed, tested, and readied for commercialization."

SBIR Phase II awardees were provided with valuable information, such as the importance of having and following a commercialization plan. NTTC will follow-up with the participating companies on any resulting commercialization developments.

Entrepreneurs typically stay focused on particular market segments based on their interest and tend to overlook other opportunities of equal or more importance, according to Richmond.

"The review provided promising opportunities," participant Dr. Kisholoy Goswami of Physical Optics Corporation, Torrance, California, said. "The board members, with diverse backgrounds, were helpful in identifying new markets that I hadn't considered."

Goswami, in his seventh quarter of NASA Phase II SBIR program, said the review emphasized the importance for a small business to have a well thought out commercialization plan and follow that plan.

Dr. Benjamin Mosier, president of Institute for Research, Inc., Houston, agrees that the review was a valuable experience for his company's commercialization efforts.

"The reviewers worked together as a single cohesive unit to formulate valuable comments, recommendations and guidelines that will enable our technology to come to fruition."

The next review will be held in March and the focus will be on composite material. ✱

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For more information, contact Sunni Richmond at NTTC. ☎ 800/678-6882, ✉ srichmond@nttc.edu Please mention you read about it in *Innovation*.

## NASA Selects 1996 STTR Phase II Awards

**N**ASA'S OFFICE OF AERONAUTICS AND SPACE Transportation Technology has selected 13 research proposals for immediate negotiation of FY 96 Phase II contracts in NASA's 1996 Small Business Technology Transfer (STTR) Pilot Program. The proposal selections are in support of the research topics included in the Agency's 1996 STTR solicitation.

A total of 32 Phase II proposals were submitted by contractors completing FY 96 STTR Solicitation Phase I projects. All proposals were peer reviewed for both technical merit and commercial potential. Selections were based on the following factors: scientific and technical merit, including the degree to which Phase I objectives were met; future importance and eventual value of the product, process, or technology results to the NASA mission; capability of the small business concern and evidence of commercial potential.

The objective of a Phase I project is to determine the feasibility of the proposed research. Phase II continues the research of the most promising Phase I projects. Each of the 13 selected Phase II proposals will be awarded a fixed-price contract valued up to \$500,000 with a performance period of up to two years.

The STTR Program is similar to the Small Business Innovation Research (SBIR) Program but varies by requiring a small business concern to conduct cooperative research and development by partnering with a research institution. At least 40 percent of the work must be performed by the small business concern, and at

## ANNOUNCEMENT

**N**ASA has selected 101 research proposals for negotiation of FY 96 Phase II contract awards for NASA's Small Business Innovation Research (SBIR) Program. The selected projects which have a total value of approximately \$59 million, will be conducted by 87 small high-technology firms located in 29 states.

Phase II continues development of the most promising SBIR 96 solicitation Phase I projects. Selection criteria include technical merit and innovation. Phase I results, value to NASA, commercial potential, and company capabilities. Funding for Phase II contracts may be up to \$600,000 for a two-year performance period.

### SBIR 97 Phase I

Solicitation Period July 30 – October 10, 1997

Review Period October 27, 1997 – January 19, 1998

Selection Notification February 9, 1998

### STTR 97 Phase I

Solicitation Period February 10 – April 22, 1997

Review Period May – June 27, 1997

Selection Notification July 14, 1997

least 30 percent of the work must be performed by the research institution.

A listing of the selected proposals can be found at URL—<http://sbir.nasa.gov> ✱

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For more information, contact Carl Ray at NASA Headquarters. ☎ 202/358-4652, 📠 202/358-3878, ✉ [cray@mail.hq.nasa.gov](mailto:cray@mail.hq.nasa.gov) Please mention you read about it in *Innovation*.

## SBIR Research Develops Eternally Visible Flame

**R**ESearch CONDUCTED BY DUNCAN TECHNOLOGIES, Inc. (DTI), of Auburn, California, through the Small Business Innovative Research Program and Stennis Space Center has developed into a revolutionary system that provides color images of invisible hydrogen fires, making it easier to detect, locate and extinguish during daylight hours.

"There's simply nothing else on the market that performs the way this system does," said Bud Nail, Stennis' technical systems lead engineer. "It takes out the guess work in identifying a hydrogen fire . . . the system does not have to be attended," and frees technicians to conduct other work with an alarm alert if a fire is detected.

Previous research using images in the infrared and near infrared to view hydrogen fires had limitations—high cost, poor resolution and difficulty in interpreting images because of thermal, rather than visible, detection.

With expertise in advanced imaging and electro-optical services expertise, DTI designed a camera system that uses state-of-the-art, low-cost, charge-coupled device (CCD) technologies to produce a color image of invisible hydrogen flames.

Using two sensors in the near infrared and one in the visible portion of the electromagnetic spectrum, a flame's strong water vapor emissions is picked up by one infrared while another detects minimal emissions, measuring the background image. The background image is subtracted from the flame image and the result is a filtered, isolated hydrogen flame image superimposed onto a color video image.

If no hydrogen fire is present, the user sees normal color video. If a flame is present, the user sees a red depiction of the flame overlaid on the color video. The system has the capability to detect a three-inch flame from up to 150 feet away.

Other fuels such as ethyl alcohol, used in the race car industry, also burn with an invisible flame. The camera can image these fires equally well and could help pit crews who deal with large quantities of this dangerous fuel in a frantic environment.

A marketing plan to commercialize this system is being developed. Potential users that could benefit from the technology are hydrogen suppliers, refineries, petroleum companies, food and semiconductor processors, the fertilizer industry and even some cosmetics companies.

Imaging technology will offer an additional margin of safety for hydrogen vehicle refueling and maintenance stations. ✱

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For more information, contact the Public Affairs Office at Stennis Space Center. ☎ 228/688-3341. Please mention you read about it in *Innovation*.



## Space Research Shines Life-Saving Light

**N**EW HOPE FOR CHILDREN WITH CANCER and the operating technique of the future may be the results of experiments of a NASA plant growth light probe developed for photodynamic cancer therapy under a NASA Small Business Innovative Research program grant managed by the Technology Transfer Office at Marshall Space Flight Center, Huntsville, Alabama.

A treatment technique called Photodynamic Therapy is using tiny pinhead-size Light Emitting Diodes (LEDs)—developed for NASA Space Shuttle plant growth experiments—to activate light-sensitive, tumor-treating drugs. Experiments indicate that when special tumor-fighting drugs are illuminated with LEDs, the tumors are more effectively destroyed than with conventional surgery.

With Food and Drug Administration approval, a drug called Photofrin II is injected into the patient's bloodstream. The drug attaches to, and permeates, the unwanted tissue without affecting surrounding tissue. The solid-state LED probe is placed near this permeated tissue, illuminating

the tumor and activating the drug to destroy the tumor cells and leaving tender brain stem tissues virtually untouched.

"The LED technology developed by NASA offers new hope to children with cancer," said Dr. Harry Whelan, pediatric neurologist of the Children's Hospital of Wisconsin, and professor of neurology at the Medical College of Milwaukee, Wisconsin. "Every one of our cases will be a critical case with no hopeful alternatives. We think this new probe will help give children with tumors a chance to live healthy, happy lives."

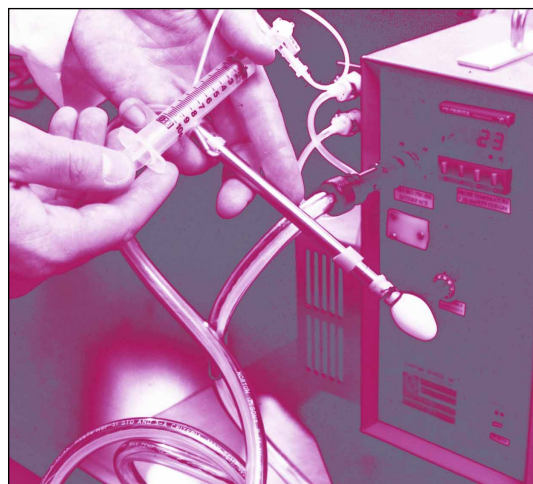
"NASA has played a number of important roles," Dr. Whelan said. "NASA has funded the development of these LEDs for space research over the years," he added. "If it wasn't for the pre-existence of all that technology, it wouldn't have been possible for us to walk right in and use it to treat cancer."

Unlike lasers and other light sources treating cancer, the LED unit can be purchased for a fraction of the cost of a laser. The advantages of the LED probe are its compact size, use for hours at a time, remains cool to the touch and is more mechanically reliable.

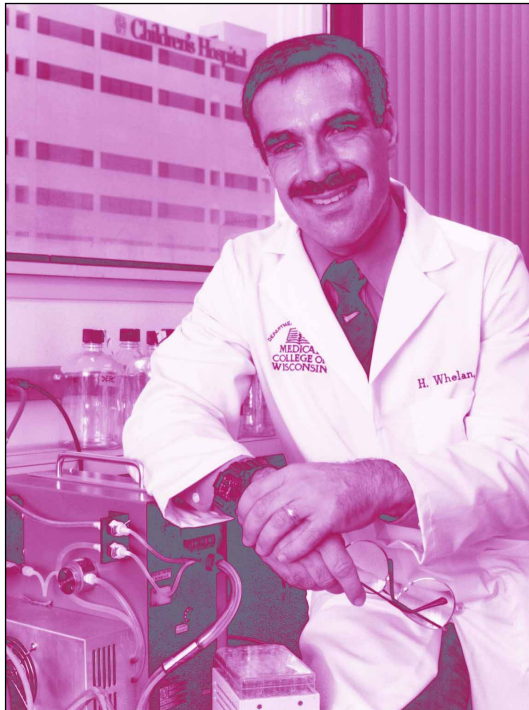
After Whelan concludes the FDA clinical trials, he anticipates full approval of what soon could be the operating technique of the future. Further research combining LEDs and promising



*A simulation of surgical implantation of the Light Emitting Diodes (LED) probe at the Children's Hospital of Wisconsin. The probe was developed for photodynamic cancer therapy under a NASA SBIR program grant.*



*The Light Emitting Diodes (LED) probe is being prepared for surgery. The LED probe consists of 144 tiny pinhead-size diodes, is nine-inches long and about one-half-inch in diameter. The small balloon aids in even distribution of the light source.*



NASA sponsored light emitting diode (LED) development helps in cancer treatment: Dr. Harry Whelan, Professor of Neurology and Pediatrics-Medicine College of Wisconsin.

new drugs are showing the possibilities of deeper tumor penetration with the probe, faster reaction times and shortened patient sensitivities to sunlight. ✱

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For more information, contact Bob Lessels at Marshall Space Flight Center. ☎ 205/544-6539 📠 205/544-4810, ✉ bob.lessels@msfc.nasa.gov Please mention you read about it in *Innovation*.

## Software Grant Applies Commercially

**S**oftware developed under a small Business Innovation Research grant has helped Dryden Flight Research Center engineers validate an automated research-flight control system (RFCS) in the F-18 High Alpha Research Vehicle (HARV) and found valuable commercial applications.

AbTech Corp. earned a NASA Tech Brief Award for developing the computer program that reduces the time and costs of validation and diagnosis of complex analog systems. It also automates the development of superior system-level diagnostic mathematical models.

The software was originally applied to the complex F-18 HARV system, but also has a wide range of business and technical applications in finance, marketing, banking, manufacturing, information systems, retail, telecommunications, healthcare and more.

It is an important tool because costs can run into the millions for validation of complex systems such as flight-control systems. It offers powerful capabilities for predicting parameters, validating sensor readings, detecting subtle anomalies and isolating equipment failures.

AbTech Corp. developed ModelQuest System Validator (MQ SV)—an advanced system-level diagnostics software—to help solve complex and time-consuming validation processes.

MQ SV is applicable to flight-control systems, engines, manufacturing processes, medical signal processing and mechanical equipment for validation of new and modified systems and simulations; system level diagnostics (anomaly detection, isolation, prediction); and comparative signal analysis (satellite telemetry, financial time-series and medical diagnostics [e.g., EKG analysis] applications).

To achieve the technical objectives, an F-18 HARV simulation developed by NASA was used. An interactive computer-based prototype of the MQ SV tool was then created to provide the support software necessary to develop, test and rapidly reprogram the validation functions. Advanced statistical network modeling technologies also were used to automate key aspects of the integrated RFCS validation process.

ModelQuest SV reduces the time and cost of validation and diagnosis of complex analog systems, increases confidence in the validity of the systems, and automates the development of superior system-level diagnostic mathematical models. ✱

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For more information contact Andrea Davis at Abtech Inc. ☎ 804/977-0686, Ext. 129 📠 804/977-9615, ✉ Adavis@abtech.com Please mention you read about it in *Innovation*.

# TECHNOLOGY OPPORTUNITY SHOWCASE

Moving Forward



## Durability, High Performance, Multi-Use

### Downhole Image Enhancement and Visualization System

NASA Technology Transfer Program at Stennis Space Center seeks commercial applications of its Downhole Image Enhancement and Visualization technology. The system includes a camera, a PC, a frame grabber, an NTSC monitor, a computer monitor, a VGA or SVGA card and an NTSC-to-VGA converter. It features visualization software that transforms information by mapping continuous downhole video onto a three-dimensional cylindrical shape that can be freely manipulated and visualized on a computer display screen. The basic image acquisition and processing system has been tested and delivered. It is manufacturable, can be modified by the user, easily maintained and is easy to use with its menu-driven operator interface. Potential commercial uses are regular inspection of oil wells and wells prepared for reactivation; inspection of pitting corrosion, stress cracks and splitting; and removal of well obstructions. ✱

activity monitor could be used in the following fields: bone and muscle physiology; gerontology research—effects of aging on ambulation, balance and falling, energy requirements; physical activity; exercise physiology; gait analysis; efficacy of sports/exercise equipment; and child and adult obesity. Further clinical data could substantiate a consumer version to monitor for exercise or weight-bearing activity for assessing individual levels of weight-bearing activity and musculoskeletal loading. ✱

For more information, contact Rick Ballard, NASA Ames Research Center. ☎ 650/ 604-1853, 📠 650/ 604-1592, ✉ rballard@mail.arc.nasa.gov or write, Mail Stop 202A-3, Moffett Field, CA 94035-1000. Please mention you read about it in *Innovation*.

### Composite Flexible Blanket Insulation

NASA Ames Research Center is seeking partnerships with industry to further develop Composite Flexible Blanket Insulation (CFBI) capabilities while continuing to lower the cost. Licensing options are also available for the manufacture and distribution of this material. It is useful as a thermal protection system for specific heating environments which contain conductive, convective and radiative heating components. It is affordable to produce from common elements. It provides flexible, durable, lightweight and high-temperature resistant insulation suitable for repeated use and can be designed to have commercially viable thermal insulation capability from 500 °C (920 °F) to 1400 °C (2550° F). It is better at protecting substructures from reaching critical temperature. It performs better by weight, can be waterproofed and has a new sewing thread capability that keeps it from breaking or tangling. Commercial manufacturing uses include firefighter suits, tools and equipment; fire shelters for smoke jumpers and front line firefighters; fire wall material for vehicles; and additional thermal and acoustic insulation. ✱

For more information, call National Technology Transfer Center Gateway Services. ☎ 800/678-6882. Please mention you read about it in *Innovation*.

### Monitoring Daily Activity in Terms of Ground Reaction Forces

NASA Ames Research Center seeks partners to use its Ground Reaction Force (GRF)-based Activity Monitor in research settings, which could lead to commercialization possibilities for a consumer monitor. The GRF Activity Monitor provides an improved method to measure, record, and analyze musculoskeletal loading histories during daily activities. It will enable research studies on bone and muscle fitness leading to a product for individuals to monitor their own daily weight-bearing activity. Potential research applications include high speed optical fiber communications, all-optical communications networks, optical computing systems and all-optical logic gates. As a research instrument, the GRF-based

For more information contact the Technology Transfer Office at Stennis Space Center. ☎ 601/688-1929 or 📠 601/688-2408. Please mention you read about it in *Innovation*.

**Technology Opportunity Showcase** highlights some unique technologies that NASA has developed and which we believe have strong potential for commercial application. While the descriptions provided here are brief, they should provide enough information to communicate the potential applications of the technology. For more detailed information, contact the person listed. Please mention that you read about it in *Innovation*.





## NASA Field Centers

**Ames Research Center**  
Selected technological strengths are Information Technologies, Aerospace Systems, Autonomous Systems for Space Flight, Computational Fluid Dynamics and Aviation Operations.

**Bruce Webbon**  
Ames Research Center  
Moffett Field, California 94035-1000  
650/604-6646  
[bwebbon@mail.arc.nasa.gov](mailto:bwebbon@mail.arc.nasa.gov)

**Dryden Flight Research Center**  
Selected technological strengths are Aerodynamics, Aeronautics Flight Testing, Aeropropulsion, Flight Systems, Thermal Testing and Integrated Systems Test and Validation.

**Eugene (Lee) Duke**  
Dryden Flight Research Center  
Edwards, California 93523-0273  
805/258-3802  
[lee.duke@dfrc.nasa.gov](mailto:lee.duke@dfrc.nasa.gov)

**Goddard Space Flight Center**  
Selected technological strengths are Earth and Planetary Science Missions, LIDAR, Cryogenic Systems, Tracking, Telemetry, Command, Optics and Sensors/Detectors.

**George Alcorn**  
Goddard Space Flight Center  
Greenbelt, Maryland 20771  
301/286-5810  
[george.e.alcorn.1@gsfc.nasa.gov](mailto:george.e.alcorn.1@gsfc.nasa.gov)

**Jet Propulsion Laboratory**  
Selected technological strengths are Deep and Near Space Mission Engineering and Operations, Microspacecraft, Space Communications, Remote and In-Situ Sensing, Microdevices, Robotics, and Autonomous Systems.

**Merle McKenzie**  
Jet Propulsion Laboratory  
Pasadena, California 91109  
818/354-2577  
[merle.mckenzie@ccmail.jpl.nasa.gov](mailto:merle.mckenzie@ccmail.jpl.nasa.gov)

**Johnson Space Center**  
Selected technological strengths are Life Sciences/Biomedical, Spacecraft Systems, Information Systems, Robotic and Human Space Flight Operations

**Henry (Hank) Davis**  
Johnson Space Center  
Houston, Texas 77058  
281/483-0474  
[henry.i.davis@jsc.nasa.gov](mailto:henry.i.davis@jsc.nasa.gov)

**Kennedy Space Center**  
Selected technological strengths are Emissions and Contamination Monitoring, Sensors, Corrosion Protection and Biosciences.

**Gale Allen**  
Kennedy Space Center  
Kennedy Space Center,  
Florida 32899  
407/867-6226  
[gale.allen-1@kmail.ksc.nasa.gov](mailto:gale.allen-1@kmail.ksc.nasa.gov)

**Langley Research Center**  
Selected technological strengths are Aerodynamics, Flight Systems, Materials, Structures, Sensors, Measurements and Information Sciences.

**Joe Heyman**  
Langley Research Center  
Hampton, Virginia 23681-0001  
757/864-6005  
[j.s.heyman@larc.nasa.gov](mailto:j.s.heyman@larc.nasa.gov)

**Lewis Research Center**  
Selected technological strengths are Aeropropulsion, Communications, Energy Technology and High Temperature Materials Research, Microgravity Science and Technology and Instrumentation Control Systems.

**Larry Viterna**  
Lewis Research Center  
Cleveland, Ohio 44135  
216/433-3884  
[Larry.A.Viterna@lerc.nasa.gov](mailto:Larry.A.Viterna@lerc.nasa.gov)

**Marshall Space Flight Center**  
Selected technological strengths are Materials, Manufacturing, Non-destructive Evaluation, Biotechnology, Space Propulsion, Controls and Dynamics, Structures and Microgravity Processing.

**Sally Little**  
Marshall Space Flight Center  
Huntsville, Alabama 35812  
205/544-4266  
[sally.little@msfc.nasa.gov](mailto:sally.little@msfc.nasa.gov)

**Stennis Space Center**  
Selected technological strengths are Propulsion Systems, Test/Monitoring, Remote Sensing and Nonintrusive Instrumentation.

**Kirk Sharp**  
Stennis Space Center  
Stennis Space Center, Mississippi  
39529-6000  
601/688-1929  
[kirk.sharp@ssc.nasa.gov](mailto:kirk.sharp@ssc.nasa.gov)

## NASA's Business Facilitators

NASA has established several organizations whose objectives are to establish joint sponsored research agreements and incubate small start-up companies with significant business promise.

Joseph C. Boeddeker  
**Ames Technology Commercialization Center**  
San Jose, CA  
408/557-6789

Lyn Stabler (Acting)  
**Mississippi Enterprise for Technology**  
Stennis Space Center, MS  
601/688-3144

Wayne P. Zeman  
**Lewis Incubator for Technology**  
Cleveland, OH  
216/586-3888

Maria Clark  
**Florida/NASA Business Incubation Center**  
Titusville, FL  
407/383-5200

## Small Business Programs

Carl Ray  
NASA Headquarters  
**Small Business Technology Transfer (SBIR/STTR)**  
202/358-4652  
[cray@hq.nasa.gov](mailto:cray@hq.nasa.gov)

Paul Mexcur  
Goddard Space Flight Center  
**Small Business Innovation Research Program (SBIR/STTR)**  
301/286-8888  
[paul.mexcur@pop700.gsfc.nasa.gov](mailto:paul.mexcur@pop700.gsfc.nasa.gov)

## NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D and foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium. To reach the RTTC nearest you, call 800/642-2872.

Ken Dozier  
**Far West Technology Transfer Center**  
University of Southern California  
213/743-2353

Dr. William Gasko  
**Center for Technology Commercialization**  
Massachusetts Technology Park  
508/870-0042

J. Ronald Thornton  
**Southern Technology Applications Center**  
University of Florida  
904/462-3913

Gary F. Sera  
**Mid-Continent Technology Transfer Center**  
Texas A&M University  
409/845-8762

Lani S. Hummel  
**Mid-Atlantic Technology Applications Center**  
University of Pittsburgh  
412/383-2500

Christopher Coburn  
**Great Lakes Industrial Technology Center**  
Battelle Memorial Institute  
440/734-0094

Joseph P. Allen (Acting)  
**National Technology Transfer Center**  
Wheeling Jesuit University  
800/678-6882

Doris Rouse  
**Research Triangle Institute Technology Applications Team**  
Research Triangle Park, NC  
919/541-6980

## NASA ON-LINE

Go to **NASA's Commercial Technology Network (CTN)** on the World Wide Web at <http://nctn.hq.nasa.gov> to search NASA technology resources, find commercialization opportunities, and learn about NASA's national network of programs, organizations, and services dedicated to technology transfer and commercialization.

## MOVING FORWARD

### Events

***Goddard Conducts Commercialization Workshops for Small Companies.*** Goddard recently held two workshops in the Boston area to assist small companies in commercializing their technology. "Making Money with Your Technology" workshops educated entrepreneurs and small business owners on topics ranging from marketing to business development to corporate partnering. Two other workshops held at Goddard in 1997 attracted over 50 participants from the Maryland region. Additional workshops at other sites are anticipated for 1998. For information about the next workshop, contact Nancy MacLennan in the Goddard Technology Commercialization Office (e-mail: [nancy.a.maclennan.1@gsfc.nasa.gov](mailto:nancy.a.maclennan.1@gsfc.nasa.gov) or phone: 301-286-6705).

NASA will present the ***International Space Station's Fifth Annual Teleconference Series*** via live and interactive satellite programs, providing a unique opportunity for students and professional groups to further knowledge in life sciences, biomedicine and biotechnology through an in-depth look at the benefits of research aboard the International Space Station.

On Thursday February 19, 12:30–2:00 p.m. (ET), ***International Space Station: Countdown to Launch*** will provide middle and high school students and teachers the opportunity to speak directly with astronauts, scientists, researchers and engineers as they discuss plans for the International Space Station.

On Thursday February 26, 1998, 1:00–3:00 p.m. (ET), ***International Space Station: Open for Business*** offers live and interactive dialog with world-class experts about International Space Station scientific and commercial research plans, opportunities and benefits. ✱

### Multimedia

Visit the online ***NASA Commercial Technology Network*** at [www.nctn.hq.nasa.gov](http://www.nctn.hq.nasa.gov) to learn about the successful transfer and commercialization of NASA technology. Click on Success Stories, to browse top stories, view the 25th edition of NASA Spinoff '97, and download the compendium of spinoffs produced by the U.S. Space Foundation. ✱



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